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Original Communication

Stature estimation from hand and phalanges lengths of Egyptians

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ABSTRACT

Estimation of stature from extremities plays an important role in identifying the deceased in forensic examinations. This study examines the relationship between stature and hand and phalanges lengths among Egyptians. Stature, hand and phalanges lengths of 159 subjects, 82 males and 77 females (18–25 years) were measured. Statistical analysis indicated that bilateral variation was insignificant for all measurements. Sex differences were significant for all measurements. Linear and multiple regression equations for stature estimation were calculated. Correlation coefficients were found to be positive, but little finger measurements of male and distal phalanges of female fingers were not correlated with stature. Regression equations were checked for accuracy by comparing the estimated stature and actual stature.

1. Introduction

Identification of an individual is the main objective of forensic investigations.[1] Stature is considered to be one of the criteria for personal identification and one of the 'big fours' of forensic anthropology.[2] Estimation of stature of an individual from the skeletal material or from the mutilated or amputated limbs or parts of limbs plays a conspicuous role in facilitating personal identification in incident of murder, accidents or natural disasters.[3] Some authors have successfully tried to estimate the stature from percutaneous body measurements,[4–14] some from isolated long bone or other bones,[15–24] some from foot dimensions,[25–28] others estimated statute from cephalo-facial anthropometry,[29,30] and some focused their attention on estimation of stature using radiographic material.[31,32] Some studies have also presented estimations of stature from hand, finger and phalange length.[33–37]

Regarding stature estimation from the Egyptian population, researchers have looked at hand length and breadth.[38] Estimations of body build using percutaneous tibeal length and bimaleolar breadth have also been studied.[39] According to Jasuja and Singh [3] there are no statistically significant difference between actual length and print length of hands or phalanges. Consequently, the purpose of the present study is to analyse the anthropometric relationship between length of hands and phalanges with stature in Egyptians and to devise regression formulae to estimate stature from these dimensions which also can be applied to hand or phalanges prints in scenes of crime.

2. Materials and methods

A sample of 159 normal healthy Egyptian volunteers (77 females and 82 males) was taken from students studying at Minia University, in the age bracket of 18–25 years. All the subjects were right handed and belonged to middle income groups. According to standard ethics drawn by the Minia University ethical committee for human experimentation, subjects were examined for stature, hand length and phalanges lengths, right and left sides. It is worth mentioning that the thumb was not considered in the present study because of its variable flexibility as compared to other fingers which are straight.

An anthropometric rod was used for the measurements of stature and a sliding calliper for hand and phalanges measurements. The measurements were taken and repeated and the mean measures were recorded (by one observer) in order to avoid inter-observer errors, and taken in centimetres to the nearest millimetres according to the techniques described by Vallois.[40] Stature is the distance from the highest point of the top of the head in the mid sagittal plane to the feet horizontal plane. The subject stood bare foot on a flat surface.[1] An Anthropometer was placed in straight vertical position in front of the subject with the head oriented in eye–ear–eye plane (Frankfurt plane). Feet axis was parallel or slightly divergent and hands hung down. The movable rod of the Anthropometer was brought into contact with the vertex in the mid sagittal plane.

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The maximum hand length was calculated to be the distance from the midpoint of distal wrist crease to the most anterior projection of the skin of the middle finger.[38] The phalange length was measured as the distance between two phalange ridges. The distal phalange length was the straight distance between the most forwarding projecting point on the tip of a finger to the first distal phalange crease.[41] Measurements were done by help of a sliding calliper from the palmer side (Figs. 1 and 2).

The data was analyzed using the statistical package of social sciences (SPSS) version 10, and regression formulae were calculated for various combinations in order to reach the best estimate possible. Statistical analysis was undertaken in accordance with Krishan and Sharma [2].

3. Results and discussion

Table 1 shows descriptive statistics for stature and measurements of hand and phalanges for both the sexes. Mean value, standard deviation, and standard error of mean of hand and phalanges lengths on both bilateral sides are presented. The values of all of the measurements in case of males are higher than in females and these sex differences are statistically significant ($p < 0.05$), by independent samples *t*-test.

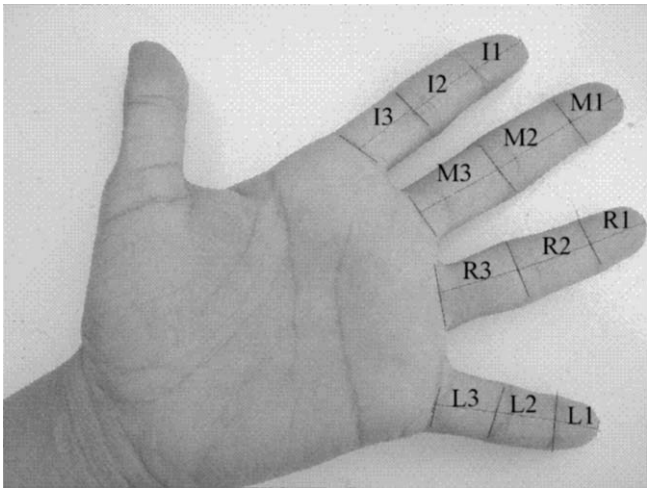

Fig. 1. Phalanges lengths of left hand of an Egyptian female.

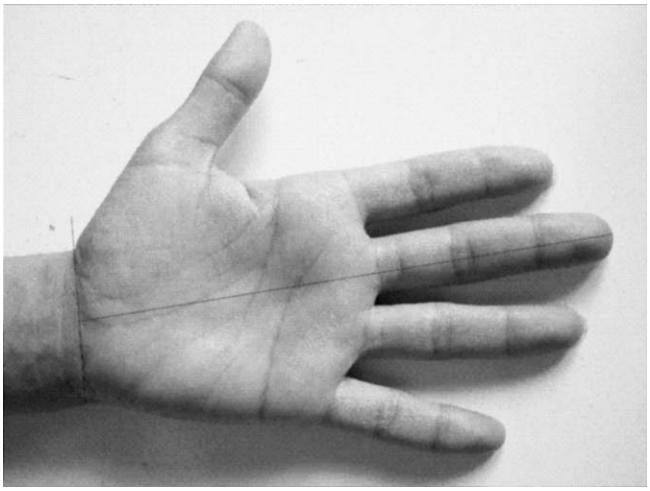

Fig. 2. Hand length of left hand of an Egyptian female.

Table 2 depicts the bilateral differences (differences in the means) in measurements of hands and phalanges for both the sexes. It is observed that there was no statistically significant bilateral difference.

Table 3 illustrates the correlation coefficients between stature and lengths of hands and phalanges on left and right sides in both the sexes. All measurements exhibit statistically significant correlation coefficients with stature ($p < 0.05$). But little finger measurements of males, and distal phalanges of females were not statistically correlated with stature. Correlation coefficients of hands lengths are higher than that of phalanges in both sexes and correlation of male hands are higher than female hands ($r = 0.697$ and 0.670 for Rt. and Lt. hands in males, and $r = 0.563$ and 0.495 for Lt. and Rt. hands in females consequently). As regards phalanges lengths, it is observed that the left distal phalange of ring finger in males (Lt.R3) shows the highest correlation with stature ($r = 0.474$), and left second phalange of middle finger in females shows the highest correlation with stature ($r = 0.469$).

Table 4 lists the regression equations of stature from hands and phalanges lengths in both sexes. In much of the literature, regression formulae are accepted as of utmost importance in the determination of stature from various anthropometric dimensions. Regression equations have been computed separately, for each sex, each side and for each measurement for the hand and phalanges. A computer analysis of the data enabled the calculation of regression coefficients '*a*' and '*b*', where '*a*' is the regression coefficient of the dependant variable i.e. stature and '*b*' is the regression coefficient of the independent variable i.e. hand and phalangeal lengths. Hence, stature = $a + bx$; where x = a length of hand or phalanges. The table also exhibits standard error of estimate (SEE) along with linear regression equations for hand length and phalangeal lengths on bilateral sides in both sexes. The SEE predicts the deviations of estimated stature from the actual stature. It ranges between ±5.30 and ±7.27 for males and between ±4.54 and ±5.48 for females. A low value indicates greater reliability in the estimated stature.

Table 5 presents multiple regression equations for the estimation of stature from different combinations of lengths of hand and phalanges in both the sexes. For males, Rt. hand length only entered with the same SEE, but for females, Lt. hand length, middle phalange of Rt. index finger (Rt.I2) and Rt. hand length were entered with smaller SEE (±4.22).

Table 6 presents a comparison of actual stature and stature estimated from lengths of hands and phalanges using linear regression equations. Mean values of the measurements were substituted in their respective regression equation and the estimated stature was calculated. For both sexes, the mean value estimates (mean estimated stature) were close to the actual stature.

The results of the present study show that the lengths of hands and phalanges can successfully be used for estimation of stature by law enforcement agencies and forensic scientists. The only precaution that must be taken into consideration is that these formulae are applicable to the population from which the data have been collected due to inherent population variations in these measurements which may be attributed to genetic and environmental factors like climate, nutrition, etc.[38,42,43]

In the present study, males show higher mean values in each anthropometric dimension than females (Table 1), this result is also corroborated by studies undertaken by others.[2,3,38] These statistically significant differences may be attributed to the early maturity of girls than boys; consequently, the boys have two more years of physical growth.[2]

As far as the bilateral asymmetry for hand length is concerned, there was no significant difference for hand length and the mean differences were trivial (Table 2). These findings are compatible with those arrived at by Abdel-Malek et al. [38], who found no sig-

Table 1
Descriptive statistics for stature and lengths of right and left hands and phalanges in both sexes.

	Male (no. 82)			Female (no. 77)			*t*-values* (sex difference)	
	Mean	SD	SEM	Mean	SD	SEM	*T*	*P*
Stature	174.61	7.34	0.81	160	5.45	0.62	13.473	0.00
Rt. hand	19.29	0.84	0.009	17.60	0.80	0.009	12.961	0.00
Rt.I1	2.32	0.22	0.002	2.23	0.20	0.002	2.637	0.00
Rt.I2	2.37	0.23	0.003	2.24	0.18	0.002	3.762	0.00
Rt.I3	2.65	0.19	0.002	2.45	0.17	0.002	6.909	0.00
Rt.M1	2.60	0.25	0.003	2.44	0.20	0.002	4.467	0.00
Rt.M2	2.78	0.25	0.003	2.55	0.26	0.003	5.734	0.00
Rt.M3	2.80	0.15	0.002	2.56	0.16	0.002	9.638	0.00
Rt.R1	2.29	0.24	0.003	2.12	0.21	0.002	4.709	0.00
Rt.R2	2.56	0.25	0.003	2.34	0.21	0.002	5.890	0.00
Rt.R3	2.76	0.17	0.002	2.52	0.18	0.002	8.538	0.00
Rt.L1	1.96	0.31	0.003	1.79	0.27	0.002	3.868	0.00
Rt.L2	1.92	0.24	0.003	1.74	0.27	0.002	4.553	0.00
Rt.L3	2.51	0.19	0.002	2.26	0.18	0.002	8.358	0.00
Lt. hand	19.36	0.86	0.009	17.62	0.77	0.009	13.500	0.00
Lt.I1	2.32	0.22	0.002	2.20	0.20	0.002	3.409	0.00
Lt.I2	2.39	0.22	0.002	2.24	0.21	0.002	4.430	0.00
Lt.I3	2.61	0.21	0.002	2.35	0.24	0.003	7.213	0.00
Lt.M1	2.60	0.24	0.003	2.24	0.19	0.002	5.126	0.00
Lt.M2	2.82	0.25	0.003	2.43	0.25	0.003	5.513	0.00
Lt.M3	2.75	0.18	0.002	2.53	0.15	0.002	8.261	0.00
Lt.R1	2.30	0.28	0.003	2.13	0.20	0.002	4.448	0.00
Lt.R2	2.59	0.24	0.003	2.36	0.20	0.002	6.333	0.00
Lt.R3	2.78	0.18	0.002	2.49	0.21	0.002	9.332	0.00
Lt.L1	1.95	0.26	0.003	1.77	0.25	0.003	4.458	0.00
Lt.L2	1.98	0.28	0.003	1.77	0.25	0.003	4.984	0.00
Lt.L3	2.49	0.28	0.003	2.26	0.22	0.003	5.558	0.00

Rt. hand = right hand, Lt. hand = left hand, Rt.I1 and Lt.I1 = right and left proximal phalanges of index finger, Rt.I2 and Lt.I2 = right and left middle phalanges of index finger, Rt.I3 and Lt.I3 = right and left distal phalanges of index finger, Rt.M1 and Lt.M1 = right and left proximal phalanges of middle finger, Rt.M2 and Lt.M2 = right and left middle phalanges of middle finger, Rt.M3 and Lt.M3 = right and left distal phalanges of middle finger, Rt.R1 and Lt.R1 = right and left proximal phalange of ring finger, Rt.R2 and Lt.R2 = right and left middle phalanges of ring finger, Rt.R3 and Lt.R3 = right and left distal phalanges of ring finger, Rt.L1 and Lt.L1 = right and left proximal phalanges of little finger, Rt.L2 and Lt.L2 = right and left middle phalanges of little finger and Rt.L3 and Lt.L3 = right and left distal phalanges of little finger.
* Significant at $p < 0.05$.

Table 2
Bilateral differences in measurements (cm) of hands and phalanges in males and females.

Variable	Males ($n = 82$)				Females ($n = 77$)			
	Mean difference (right-left)	SD	*t*-value	*P*	Mean difference (right-left)	SD	*t*-value	*P*
Hand L	−0.007	0.26	2.41	0.018	0.001	0.23	0.54	0.588
I1	0.0006	0.13	0.43	0.670	0.003	0.15	1.76	0.083
I2	0.002	0.15.	1.20	0.233	0.0009	0.15	0.52	0.608
I3	0.004	0.18	2.14	0.035	0.1013	0.21	4.26[a]	0.000
M1	−0.0007	0.15	0.40	0.690	0.001	0.14	0.75	0.453
M2	−0.004	0.16	2.17	0.033	0.005	0.16	2.82	0.006
M3	0.005	0.12	3.50	0.001	0.003	9.44 E−02	2.66	0.010
R1	−0.001	0.21	0.48	0.636	0.0006	0.1490	0.398	0.703
R2	−0.003	0.13	2.05	0.043	0.002	0.1331	1.33	0.188
R3	−0.002	0.11	1.57	0.121	0.002	0.15	1.44	0.155
L1	0.001	0.27	0.39	0.700	0.001.	0.23	0.57	0.572
L2	−0.007	0.27	7.26	0.026	0.004	0.23	1.57	0.120
L3	0.002	0.22	0.85	0.398	0.0001	0.16	0.07	0.942

nificant bilateral difference in hand length in either sexes of Upper Egyptian adults. Also other studies, such as Krishan and Sharma [2], and Schell et al. [44] suggest that there were no significant bilateral differences in hand length in either sexes of Northern Indian population. However study of Rastogi et al. [45] revealed that right hand length is significantly higher than left hand length in North and Southern Indians. Further, Krishan and Sharma [46], in their study showed significant asymmetry in hand length among the Punjabi adolescents. As regards bilateral asymmetry for phalanges lengths, the mean differences also were not significantly different. There is a paucity of literature on bilateral asymmetry in phalange length of Egyptians or other population groups.

Hand length in both the sexes showed higher correlation coefficients with stature (Table 3). Thus, hand length is a good parameter for estimating stature. This was also supported by lower SEE and higher R^2 in case of hand length in both the sexes (Table 4). This result is in concordance with Saxena [36] who reported a statistically significant correlation between stature and hand length. Abdel-Malek et al. [38], and others [2,45,3] achieved the same result.

Phalanges lengths have a positive as well as a statistically significant correlation with the stature (Table 3), this was also found by Jasuja and Singh [3], who studied all the three phalanges of each finger of Punjabi Jat Sikhs, and also found by Shintaku and Furuya

Table 3
Correlation between stature and anthropometric measurements.

Variable	Value of *r*			
	Male		Female	
	Right	Left	Right	Left
Hand L	0.697**	0.670**	0.495**	0.563**
Index:I1	0.294**	0.365**	0.245*	0.124
I2	0.350**	0.288**	0.458**	0.448**
I3	0.365**	0.252*	0.375**	0.232*
Middle:M1	0.427**	0.445**	0.226*	0.298**
M2	0.383**	0.283*	0.363**	0.469**
M3	0.393**	0.410**	0.462**	0.352**
Ring:R1	0.300**	0.235*	0.132	0.167
R2	0.375**	0.368**	0.444**	0.433**
R3	0.443**	0.474**	0.370**	0.366**
Little:L1	0.283**	0.174	0.055	0.166
L2	0.198	0.217	0.235*	0.247*
L3	0.367**	0.410**	0.443**	0.420**

* Significant at 0.05 level (2-tailed).
** Significant at 0.01 level (2- tailed).

[34] who reported a correlation of proximal phalange and stature for Japanese women. It is also noticed that Egyptian females exhibit a low SEE (±4.54–5.48 cm) and a relatively higher correlation coefficient between stature and lengths of hands and phalanges than those observed in their male counterparts (SEE ± 5.30–7.27 cm) (Table 4). This suggests that the accuracy in predicted stature would be greater among females than in males. Similar results were reported by Krishan and Sharma [2] on their study of a North Indian population. According to Jasuja and Singh [3], measurements of impressions or prints which sometimes can be found at scenes of crimes, accidents, or natural disasters are valuable in identification.

Stepwise regression equation (Table 5), showed that only the right hand is sufficient for estimation of stature in males, However, for females, multiple regression equations are better indicators of stature estimation than linear regression equations, and phalanges

Table 5
Multiple (stepwise) regression equations for estimation of stature (cm) from hand and phalange lengths in both sexes.

Males		Females	
Multiple regression equations	±SEE	Multiple regression equations	±SEE
S = 57.70 + 6.06 × Rt. hand L	±5.30	90.15 + 4.01 × Lt. hand L	±4.54
		85.95 + 3.21 × Lt. hand L + 8.12 × Rt.I2	±4.35
		85.34 + 8.20 × Lt. hand L + 9.72 × Rt.I2 + 5.16 × Rt. hand L	±4.22

Table 6
Comparison of the actual stature and stature estimated (cm) from lengths of hand and phalanges.

Estimated stature using regression equations for males		Mean estimated stature using regression equations for females	
Rt. hand	174.59	Hand	160.82
Lt. hand	174.63	I1	160.74
I1	174.60	I2	160.72
I2	174.61	Rt.I3	160.67
Rt.I3	174.61	Lt.I3	160.74
Lt.I3	174.61	M1	160.72
M1	174.61	Rt.M2	160.74
Rt.M2	174.60	Lt.M2	160.73
Lt.M2	174.59	Rt.M3	160.72
Rt.M3	174.62	Lt.M3	160.73
Lt.M3	174.61	R1	160.73
R1	174.62	R2	160.72
Rt.R2	174.61	R3	160.72
Lt.R2	174.62	L1	160.74
R3	174.62	L2	160.73
L1	174.61	L3	160.72
Rt.L2	174.61		
Lt.L2	174.61		
L3	174.61		
Mean actual stature For males: 174.61		Mean actual stature For females: 160	

Table 4
Linear regression equations for estimation of stature (cm) from lengths of hands and phalanges.

Males			Females		
Regression equation	±SEE	R^2	Regression equation	±SEE	R^2
S = 57.70 + 6.06 × Rt. hand L	±5.30	0.49	S = 101.13 + 3.39 × Rt. hand L	±4.77	0.25
S = 63.49 + 5.74 × Lt. hand L	±5.48	0.45	S = 90.15 + 4.01 × Lt. hand L	±4.54	0.32
S = 151.88 + 9.79 × Rt.I1	±7.06	0.08	S = 145.78 + 6.69 × Rt.I1	±5.32	0.06
S = 145.95 + 12.38 × Lt.I1	±6.87	0.13	S = 153.27 + 3.39 × Lt.I1	±5.45	0.02
S = 148.38 + 11.07 × Rt.I2	±6.92	0.12	S = 130.26 + 13.58 × Rt.I2	±4.88	0.21
S = 152.03 + 9.46 × Lt.I2	±7.07	0.08	S = 135.19 + 11.43 × Lt.I2	±4.91	0.20
S = 137.24 + 14.09 × Rt.I3	±6.87	0.13	S = 131.17 + 12.04 × Rt.I3	±5.09	0.14
S = 151.64 + 8.80 × Lt.I3	±7.15	0.06	S = 148.24 + 5.31 × Lt.I3	±5.34	0.05
S = 141.38 + 12.80 × Rt.M1	±6.68	0.18	S = 145.48 + 6.26 × Rt.M1	±5.35	0.05
S = 139.22 + 13.60 × Lt.M1	±6.61	0.20	S = 139.92 + 8.58 × Lt.M1	±5.24	0.09
S = 143.38 + 11.22 × Rt.M2	±6.82	0.15	S = 140.98 + 7.74 × Rt.M2	±5.11	0.13
S = 150.89 + 8.40 × Lt.M2	±7.08	0.08	S = 134.44 + 10.10 × Lt.M2	±4.85	0.22
S = 121.16 + 19.10 × Rt.M3	±6.79	0.16	S = 121.24 + 15.43 × Rt.M3	±4.87	0.21
S = 129.58 + 16.36 × Lt.M3	±6.73	0.17	S = 129.01 + 12.54 × Lt.M3	±5.14	0.12
S = 153.49 + 9.22 × Rt.R1	±7.04	0.09	S = 153.32 + 3.49 × Rt.R1	±5.44	0.02
S = 160.26 + 6.24 × Lt.R1	±7.18	0.06	S = 151.02 + 4.56 × Lt.R1	±5.41	0.03
S = 146.90 + 10.84 × Rt.R2	±6.85	0.14	S = 133.20 + 11.77 × Rt.R2	±4.92	0.20
S = 145.95 + 11.09 × Lt.R2	±6.87	0.14	S = 133.19 + 11.67 × Lt.R2	±4.95	0.19
S = 123.28 + 18.60 × Rt.R3	±6.62	0.20	S = 132.50 + 11.21 × Rt.R3	±5.10	0.21
S = 120.01 + 19.65 × Lt.R3	±6.50	0.22	S = 136.71 + 9.63 × Lt.R3	±5.11	0.13
S = 161.46 + 6.70 × Rt.L1	±7.08	0.08	S = 158.71 + 1.13 × Rt.L1	±5.48	0.00
S = 164.94 + 4.96 × Lt.L1	±7.27	0.03	S = 154.66 + 3.43 × Lt.L1	±5.42	0.03
S = 163.21 + 5.95 × Rt.L2	±7.24	0.04	S = 152.43 + 4.80 × Rt.L2	±5.33	0.06
S = 163.25 + 5.73 × Lt.L2	±7.21	0.05	S = 151.29 + 5.33 × Lt.L2	±5.32	0.06
S = 139.58 + 13.97 × Rt.L3	±6.87	0.14	S = 129.58 + 13.77 × Rt.L3	±4.92	0.20
S = 147.56 + 10.88 × Lt.L3	±6.73	0.17	S = 137.67 + 10.19Lt.L3	±4.98	0.18

S = stature, Rt. hand L = right hand length, Lt. hand L = Left hand length.

have a role in stature estimation. This difference in males and females here highlights the importance of biologic/environmental factors [34].

4. Conclusion and recommendation

It is concluded that hand and phalange length (or of their prints according to Jasuja and Singh [3]) are highly reliable for the estimation of stature in forensic examinations. Hand length gives better prediction of stature than that of phalange in both sexes. Stature prediction is more reliable in case of Egyptian females than in males. The regression equations were derived from hand and phalange lengths and indicated that the stature can be estimated from them with SEE ranging from +4.54 to ±7.27 cm for both sexes.

Conflict of Interest

Estimation of stature from any body remains especially hands and/or phalanges, which has an importance in forensic medicine in our country (Egypt).

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None declared.

Ethical Approval

This study was done according to standards drawn by Minia university ethical committee for human experimentation (as shown in materials and methods), in addition, volunteers shared this study were consenting before any measurements taken.

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